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*III. A PRELIMINARY ATTEMPT TO DEVISE A TEST OF THE ABILITY OF HIGH-SCHOOL PUPILS IN THE MENTAL MANIPULATION OF SPACE RELATIONS

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DIRECTIONS FOR GIVING EACH TEST

The primary purpose of this test is to compel the pupil to get the answer to each question through mental manipulation of the data involved solely and without any assistance from drawings or other external devices.

To this end the teacher is asked to observe the following procedure in giving the test:

1. Pupils clear desks of all books, papers, etc., and have pencil or pen only before them.
2. The teacher passes out the test to the pupils telling them they may read the first page of directions but may not turn over the page.
3. Pupils fill out the blanks on the first page.
4. As soon as the blanks are filled out the teacher reads over to the pupils the directions on the first page of the test.
5. Noting the time, the teacher announces: You may turn over the page and begin.
6. At the end of exactly 30 minutes all pupils stop work and hand in papers immediately. Those who have answered all questions before the time expires hand in papers as soon as they have done so.
7. During the 30 minutes occasional observation of the pupils is necessary to prevent some from using external devices to get the answer, e.g., drawing figures on the margin, folding paper, using coins, etc.

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*Continued from page 670 of the November issue of the *Review*.

DIRECTIONS TO PUPILS

Fill in the following:

Date............................ School..........................
Name............................ Age.................(nearest year)
Class........................... Period...........Room...........

Write below the subjects which you are studying this semester:

....
....
....

The following pages contain questions which you are to answer exactly as follows:

1. Read the question carefully.
2. Decide upon the answer in your mind and without using your pencil or hand in any way.
3. Write the answer in the blank space after the question or make the drawing which the question asks you to make.

Answer as many questions as you can but do not hurry.

Take time enough to get the correct answer.

Remember you are to decide upon the answer in your mind and without using your pencil; draw a figure only when the question asks for one.

TEST C

1. A circular piece of paper is folded through the center so that the curved edges fall together. This is then folded a second time making all the edges fall together, and this is folded again in the same way. After the third folding, into how many parts is the piece of paper divided by the creases?..............

2. I wish to draw a square on the blackboard and then to divide it into four equal small squares. What is the least number of straight lines that must be drawn to do this?......

3. Five pennies are placed side by side in a row on the table. A second row is placed above these so that each penny touches two pennies in the first row. How many pennies are there in the second row?............... How many pennies in a third row placed in the same way?..............

4. In the drawing below A is to be placed on either B or C so that the thick line in A will fall on the thick line in B or C. A may be moved around but not turned over. Upon which figure can A be placed?..............Mark where the circle in A will fall on this figure.

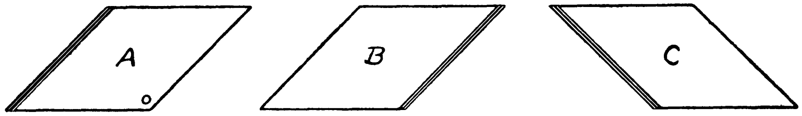

Figure 5

5. I wish to make a cardboard box having a three-cornered bottom, three equal sides with square corners, and a top of the same shape and size as the bottom. The box is to be made out of a single piece of cardboard. Draw the piece of cardboard as you would cut it, and show by dotted lines where it is to be creased when folded to make the box.

6. A man starts in a car from town A, rides ten miles south to B, then ten miles west to C, then ten miles south to D. A second man goes from A to D riding west till he is just north of D, then riding south to D. How many miles west does the second man go?.............. How many miles south does he go?..............

7. In the figure at the right the distance around circle A is equal to twice the distance around circle B. Imagine circle A held in place while circle B is rolled completely around it. Make a drawing of the path which point X will follow as circle B is rolled around circle A.

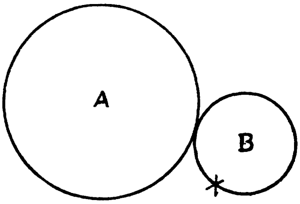

Figure 6

8. I have a square piece of paper on the desk in front of me. I fold it once, placing the upper left hand corner on the lower right hand corner and creasing. I then fold this, placing the lower left hand corner and upper right hand corner side by side on the lower right hand corner and creasing. I now fold this, placing the upper right hand corner of it on the lower left hand corner and creasing. Make a drawing of the paper as it will appear to me when unfolded, showing the creases.

9. A carpenter has a block of wood that is a perfect cube. How many times must he saw through the entire block to divide it into eight equal small cubes?

10. The circle at the right represents a round metal disk like a victrola record that is made to rotate or turn about its center X, in the direction shown by the arrow. As it rotates a needle point moves from A across the disk to X and back again to A in the same time that it takes the disk to make half a complete turn. Draw a line on the disk showing the path followed by the needle point.

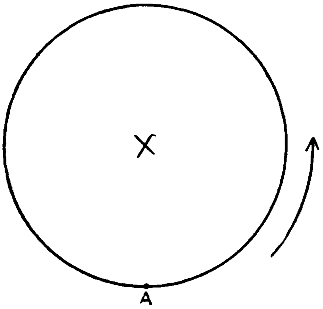

Figure 7

11. What is the least number of times that a square piece of paper must be folded so that the creases will divide it into 16 small squares?..............

12. A square cake is cut by drawing a knife from each corner to the opposite corner and from the middle of each side to the middle of the opposite side. How may strokes does the knife make?.............. Into how many pieces is the cake cut?..............

13. Five barrels are lying in a row on the ground with sides touching and kept from rolling apart by a short stake at each end of the row. A second row of barrels is piled on top of this first row, a third row on the second, and so on. Altogether how many barrels can be thus piled above the first row of five?

14. In the drawing below A is to be placed on either B or C so that the thick line in A will fall on the thick line in B or C. A may be moved around but not turned over. Upon which figure can A be placed?............... Mark where the circle in A will fall on this figure.

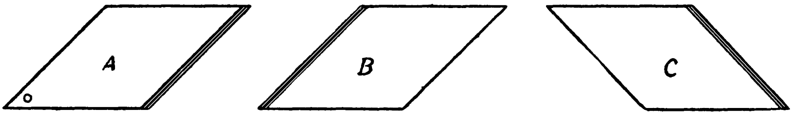

Figure 8

15. I wish to make a cardboard pyramid having a three-cornered bottom and three sides meeting at the top in a point. The bottom and sides are all to be of the same shape and size. The pyramid is to be made out of a single piece of cardboard. Draw the piece of cardboard as you would cut it, and show by dotted lines where it is to be creased to make the pyramid.

16. A man starts in a car from town A, rides ten miles east to B, then ten miles north to C, then ten miles east to D. A second man goes from A to D riding north till he is just west of D, then riding east to D. How many miles north does the second man go?............... How many miles east does he go?.............

17. In the figure at the right the distance around the large circle is equal to three times the distance around the small circle. Imagine the large circle held in place while the small circle is rolled completely around inside it. Make a drawing of the path which point X will follow as the small circle is rolled around inside the large circle.

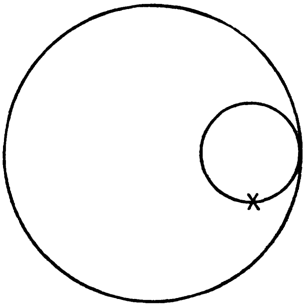

Figure 9

18. I have a square piece of paper on the desk in front of me. I fold it once, placing the lower left hand corner on the upper right hand corner and creasing. I then bring the upper

left hand corner, lower right hand corner, and upper right hand corner of this folded piece together at the midpoint of the folded edge and crease. Make a drawing of the paper as it will appear to me when unfolded showing the creases.

19. A block of wood in the shape of a cube is painted on all sides. It is then cut into eight equal small cubes. How many of these small cubes are painted on two sides only?.......... on three sides only?.........; on four sides only?..........

20. The circle at the right represents a round metal disk like a victrola record that is made to rotate or turn about its center X, in the direction shown by the arrow. As it rotates a needle point moves from A across the disk to X and back again to A in the same time that it takes the disk to make one complete turn. Draw a line on the disk showing the path followed by the needle point.

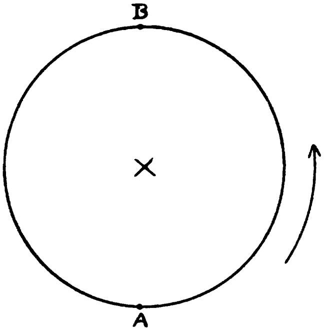

Figure 10

21. If you take a sheet of paper, fold it once making the bottom edge fall on the top, fold it a second time making the folded edge fall on the top, then fold it a third time in the same way, how many layers of paper have you after the last folding?..............

22. I wish to draw a square on the blackboard and then to divide it into nine smaller squares. What is the least number of straight lines that must be drawn to do this?..............

23. Six tennis balls are laying side by side in the form of a circle upon a table. How many tennis balls can you place around the outside of this circle of six balls if each ball that you place on the table must touch two of the six balls already laying there?..............

24. In the drawing below A is to be turned over and then placed on either B or C so that the thick line in A will fall on

the thick line in B or C. Upon which figure can A be placed after it is turned over?............... Mark where the circle in A will fall on this figure.

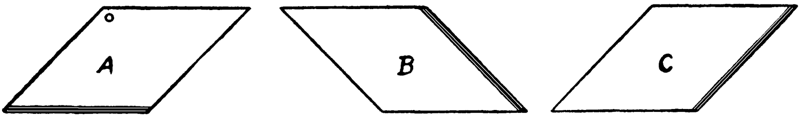

Figure 11

25. I wish to make a cardboard box 15 inches long, 10 inches wide, and 5 inches high, and having a bottom, two sides, two ends, and a top. The box is to be made out of a single piece of cardboard. Draw the piece of cardboard as you would cut it, and show by dotted lines where it is to be creased to make the box.

26. A man starts in a car from town A, rides twenty miles west to B, then twenty miles north to C, then ten miles east to D, then five miles south to E. A second man goes from A to E, riding west until he is just south of E, then riding north to E. How many miles west does the second man go?.............. How many miles north does he go?..............

27. In the figure below make a drawing to show the path which point A will follow as the oblong curve is rolled over and over on the straight line until it reaches the other end of the line:

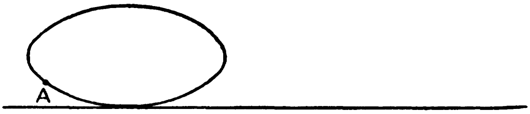

Figure 12

28. I have a square piece of paper on the desk in front of me. I fold over the top half, making the top edge fall on the bottom edge and creasing. I next fold up the lower left hand and lower right hand corners of this, making them fall side by side along the folded edge. I now fold over the left half of this making it fall on the right half edge to edge. Make a

drawing of the paper as it will appear to me when unfolded, showing the creases................

29. A block of wood in the shape of a cube is painted on all sides. It is then cut into 27 equal small cubes. How many of these small cubes are painted on one side only?..........; on two sides only?............; on three sides only?............

30. The circle at the right represents a round metal disk like a victrola record that is made to rotate or turn about its center X, in the direction shown by the arrow. As it rotates a needle point moves from A across the disk to X and back again to A in the same time that it takes the disk to make two complete turns. Draw a line on the disk showing the path followed by the needle point.

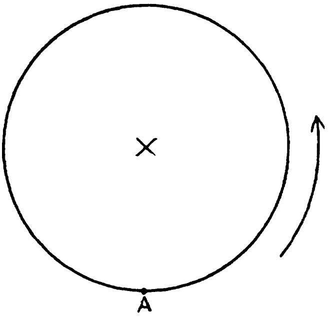

Figure 13

TEST D

1. A pupil has a sheet of paper 14 inches long and 10 inches wide. On it he wishes to draw a map so that there will be a space of 2 inches left between each edge of the map and the edge of the paper. What must be the length and width of the map? Length............Width............

2. It is 5:12 o'clock. Suppose the hands change places so that the large hand takes the place of the small hand while the small hand takes the place of the large hand; what time would it then be?..............

3. A square sheet of paper eight inches long on each side is to be divided by lines into small squares two inches long on each side. How many lines must be drawn across the sheet of paper to do this?..............

4. Four points are placed on the blackboard as if they represented the corners of a four-sided figure. How many different straight lines can be drawn between these points?...........

5. Using the letters and arrows only show how you would place A, B, C, D, and E, in the large square so as to fill it. The numbers show the size. A, B, C, D, and E, may be turned around or over in any way. Use the letters and arrows only to show where you would place them. Draw no lines in the large square.

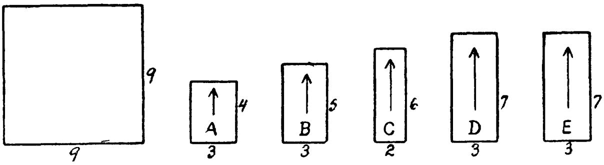

Figure 14

6. Three men, A, B, and C, start from the same point, A going north three miles, B going east three miles, and C going west three miles. If the straight line distance between them is measured which men are farthest apart?..............
Which men are the same distance apart?..............

7. A boy has a square box lid in which he can lay just three rows of three marbles each. If now he places on top of this first layer of marbles a second layer in which each marble touches four marbles of the first layer, how many marbles are there in the second layer?..............

8. In the figure below make a drawing to show the path which point A will follow as the triangle is rolled over and over on the straight line until it reaches the other end of the line.

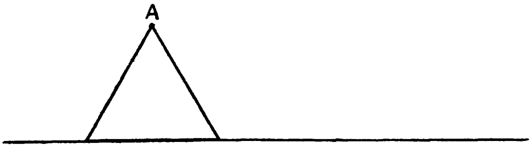

Figure 15

9. I have a square piece of paper on the desk in front of me. I fold it once placing the bottom edge on the top edge and creasing. I then fold over the left half of this placing the left edge on the right edge and creasing. I next cut a small piece

out of the middle of the folded edge on my left. Make a drawing of the paper as it will appear to me when unfolded, showing the creases and what results from the cutting.

10. The circle at the right represents a round metal disk like a victrola record that is made to rotate or turn about its center X, in the direction shown by the arrow. As it rotates a needle point moves from A, across the disk through X to B, and back again to A, in the same time that it takes the disk to make half a complete turn. Draw a line on the disk showing the path followed by the needle point.

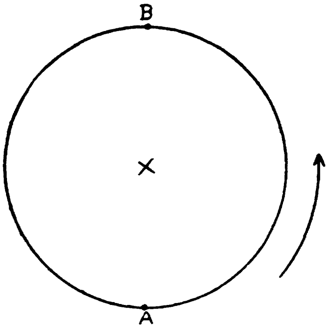

Figure 16

11. A pupil has a square sheet of paper 10 inches long on a side, in the middle of which he draws a square 4 inches long on a side, each side of the square being the same distance from the edge of the sheet of paper. What is this distance?..........

12. It is 6:48 o'clock. Suppose the hands change places so that the large hand takes the place of the small hand while the small hand takes the place of the large hand; what time would it then be?.............

13. Four lines are drawn on the blackboard each one inch apart. Four other lines also one inch apart are then drawn across these in such a way as to make a number of one inch squares. How many squares are thus made?..............

14. A box is to be drawn on the blackboard, each edge being represented by either a solid or dotted line. Altogether how many solid and dotted lines must be drawn?............

15. Using the letters and arrows only show how you would place A, B, C, D, E, and F, in the large square so as to fill it. The numbers show the size. A, B, C, D, E, and F may be turned around or over it any way. Use the letters and arrows

only to show how you would place them. Draw no lines in the large square.

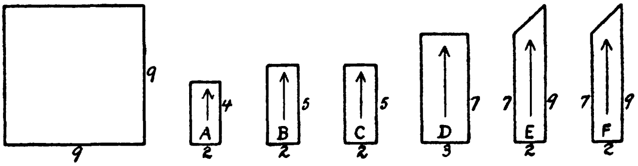

Figure 17

16. Three men, A, B, and C, start from the same point, A going west five miles, B going south five miles, and C going north five miles. If the straight line distance between them is measured which men are the farthest apart?............... Which men are the same distance apart?...............

17. In a show-case there is a pile of tennis balls arranged thus: At the top is a single ball which rests on a layer of four balls arranged in the form of a square and touching each other. Each of these four balls in turn rests on four balls in the next layer. How many balls are there in the layer directly under the four balls?...............

18. In the figure below make a drawing to show the path which point A will follow as the square is rolled over and over on the straight line until it reaches the other end of the line.

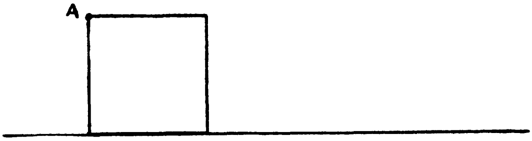

Figure 18

19. I have a square piece of paper on the desk in front of me. I fold it once, placing the lower left hand corner on the upper right hand corner and creasing. I then fold this, placing the lower right hand corner on the upper left hand corner and creasing. I next cut a small piece out of the middle of the folded edge on my right. Make a drawing of the paper as it will appear to me when unfolded, showing the creases and what results from the cutting.

20. The circle at the right represents a round metal disk like a victrola record that is made to rotate or turn about its center X, in the direction shown by the arrow. As it rotates a needle point moves from A, across the disk through X to B, and back again to A, in the same time that it takes the disk to make one complete turn. Draw a line on the disk showing the path followed by the needle point.

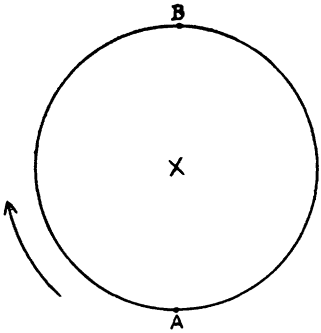

Figure 19

21. A photographer has a picture 24 inches long and 18 inches wide which he wishes to mount on a piece of cardboard so that each edge of the picture will be 3 inches from the edge of the cardboard. What must be the length and width of the cardboard? Length.............. Width...............

22. It is 2:36 o'clock. Suppose the hands change places so that the large hand takes the place of the small hand while the small hand takes the place of the large hand; what time would it then be?..............

23. In making a certain square cushion upholstery buttons are sewed on top of the cushion as follows: The buttons are arranged in rows 5 inches apart and 5 inches from the edge of the cushion. The buttons in each row are also 5 inches apart and 5 inches from the edge of the cushion. How many buttons are needed for the top of a square cushion 25 inches long on each side?..............

24. A square cornered trunk with open lid is to be drawn, using a straight line to represent each edge of the top and each edge of the bottom except the edge of the top and the edge of the bottom along which the hinges are fastened. Since these two edges come together they are to be represented by one line. Each of the other edges is to be represented by a

separate straight line. How many lines must be drawn to represent the entire figure?. . . . .

25. Using the letters and arrows only show how you would place A, B, C, D, E, F, H, K, in the large square so as to fill it. The numbers show the size. A, B, C, D, E, F, H, and K, may be turned around or over in any way. Use the letters and arrows only to show where you would place them. Draw no lines in the large square.

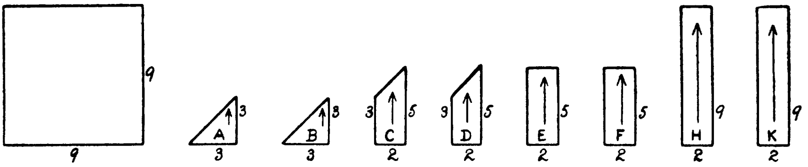

Figure 20

26. Three men, A, B, and C, start from the same point, A going northwest ten miles, B going southeast ten miles, and C going southwest ten miles. If the straight line distance between them is measured which men are the farthest apart? . . . . Which men are the same distance apart? . . . .

27. I have a small three-cornered box along any one side of which I can just fit a single row of three tennis balls. Altogether how many tennis balls can I place in the box?. . . . .

28. In the figure below make a drawing to show the path which point A will follow as the five-sided figure is rolled over and over on the straight line until it reaches the other end of the line.

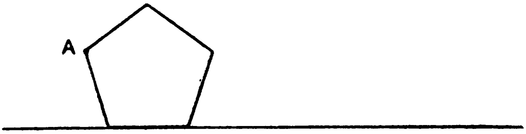

Figure 21

29. I have a square piece of paper on the desk in front of me. I fold it once placing the right edge on the left edge and

creasing. I then fold up the lower half of this placing the bottom edge on the top edge and creasing. I next cut a hole through the middle of this while keeping it folded. Make a drawing of the paper as it will appear to me when unfolded showing the creases and what results from cutting the hole through the folded paper.

30. The circle at the right represents a round metal disk like a victrola record that is made to rotate or turn about its center X, in the direction shown by the arrow. As it rotates a needle point moves from A, across the disk through X to B, and back again to A, in the same time that it takes the disk to make two complete turns. Draw a line on the disk showing the path followed by the needle point.

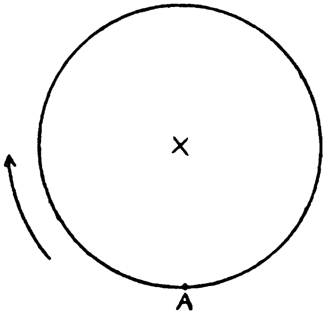

Figure 22